

**SHIP PRODUCTION COMMITTEE
FACILITIES AND ENVIRONMENTAL EFFECTS
SURFACE PREPARATION AND COATINGS
DESIGN/PRODUCTION INTEGRATION
HUMAN RESOURCE INNOVATION
MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING**

**September 1991
NSRP 0340**

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

**1991 Ship Production Symposium
Proceedings:**

Paper No. IXB-1

**The Eight-Hour Workday: An Unat-
tainable Goal**

**U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER**

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE SEP 1991		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE The National Shipbuilding Research Program, 1991 Ship Production Symposium Proceedings: Paper No. IXB-1: The Eight-Hour Workday: An Unattainable Goal				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Surface Warfare Center CD Code 2230-Design Integration Tools Bldg 192, Room 128 9500 MacArthur Blvd, Bethesda, MD 20817-5700				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 8	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

DISCLAIMER

These reports were prepared as an account of government-sponsored work. Neither the United States, nor the United States Navy, nor any person acting on behalf of the United States Navy (A) makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness or usefulness of the information contained in this report/manual, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or (B) assumes any liabilities with respect to the use of or for damages resulting from the use of any information, apparatus, method, or process disclosed in the report. As used in the above, "Persons acting on behalf of the United States Navy" includes any employee, contractor, or subcontractor to the contractor of the United States Navy to the extent that such employee, contractor, or subcontractor to the contractor prepares, handles, or distributes, or provides access to any information pursuant to his employment or contract or subcontract to the contractor with the United States Navy. ANY POSSIBLE IMPLIED WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR PURPOSE ARE SPECIFICALLY DISCLAIMED.



THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS
601 Pavonia Avenue, Jersey City, N.J. 07306

Paper presented at the 1991 Ship Production Symposium,
The Pan Pacific Hotel, San Diego, California, September 3-6, 1991.

The Eight-Hour Workday: An Unattainable Goal

IXB-1

Alan J. Kaitz, Visitor, and James R. Miller, Member, Philadelphia Naval Shipyard

ABSTRACT

No industrial operator can be fully productive for an entire shift. Interference with the productive process occurs during the work day that is beyond the operator's control.

Once the industrial engineering analyst has produced a normal time for an operation, the standard is still not complete. The analyst must account for personal, fatigue, and delay (PF&D) time and factor the appropriate allowances into the normal time to produce a true standard time. Allowing for personal needs is usually not enough. Operators experience fatigue due to the stress factors that are abundant in ship repair processes. Delays are incurred when multiple trades must combine their skills to complete one work cycle. These personal, fatigue, and delay factors are steadily increasing, as technological, safety, and environmental needs are discovered, making many processes more complicated. Some other factors that affect the work day are: mustering of personnel for shift changes; preparing turn-over reports for ensuing shifts; attending to administrative requirements; and general work area cleaning.

INTRODUCTION

To accurately account for all of the factors affecting the work day, the industrial engineering analyst must become familiar with the nature of the work, the environment in which it is performed, and all governing regulations. Since it is not unusual for operators to take short-cuts, especially where safety and environmental requirements are concerned, it is important that the analyst develops personal, fatigue, and delay allowances in compliance with existing regulations. In ship repair work, allowances for similar operations may vary widely from one work cycle to

another, depending on conditions and requirements. Welding in a tank, for example, requires considerably greater allowances for working conditions and safety than welding on an open bulkhead. The analyst cannot afford to apply a general factor but must develop an individualized allowance for each operation based on personal observations and experience with the actual conditions. Developing a PF&D allowance is an integral part of determining direct labor charges.

To illustrate the development of PF&D allowances as this paper progresses, a running example will be created using the Department of Defense (DoD) requirements (1). The example will consist of an electrician mounting a 40-pound piece of electrical equipment at waist level in a ship's machinery space.

PERSONAL TIME

Workers must attend to personal needs, such as going to the rest room, getting fresh air, or getting a drink. Allowances for these personal needs are usually defined by company policy or negotiated into a labor-management agreement and do not have to be redefined for each job. For example, the Department of Defense personal time allowances are 9 percent for indoor (shop) work and 14 percent for outdoor (shipboard) work (1).

If the analyst needs to develop personal time allowances, the best approach is through a work-sampling (ratio-delay) study. Company policy regarding personal time should be defined before beginning the study. The items to be observed are primarily trips to the restroom and drinking fountain, getting fresh air, special clothing requirements (for example, 'clean-room' garb) and, where applicable, lunch breaks (1). Criteria to be considered are the distances the worker must travel to use the

facilities and the disruption to the job that the trips cause, such as having to store tools or secure the job before leaving the work site. Items such as rest breaks or changing safety equipment are not normally considered personal time. The results of the study should be reviewed with management and labor before they are applied, as these parties often disagree on this type of allowance.

FATIGUE

The study of fatigue in workers. and the development of allowances to compensate for it, is a point where many analysts disagree when applying PF&D allowances. Every operator works at a slower pace towards the end of the shift than at the beginning (2). This slowing is more apparent in some workers than in others. Fatigue is greater in ship repair than on the typical progressive assembly line, due to the multiple stresses on workers and the less-than-favorable working conditions aboard a ship under repair. Pace rating will not adjust the normal time for this slowing since the change in pace is not consistent. A standard developed by motion-time analysis has the pace rating built in and does not reflect the normal slowing of a worker throughout the work day. Some organizations create standard allowances for fatigue (1). They may be included in a labor-management agreement. Scheduled morning and afternoon rest breaks, normally 5-15 minutes each (2), are a common way to compensate for worker fatigue.

The two stresses that create worker fatigue are mental and physical. Concentration, lighting, temperature, humidity, air quality, color of the work area, and noise are all factors that affect mental stress. Physical stress is caused by working position (sitting, standing, walking, and cramped quarters (1). weight handling, repetitive motions, and disagreeable working conditions (3).

Mental Stress

A worker is more fatigued by work that requires intense concentration than by work that is largely habitual, although monotony from highly repetitive. short-cycle work will also cause fatigue. Glare from a work surface or inadequate lighting (less than 75 foot-candles for normal work or 125 foot-candles for close work (1)) creates worker fatigue. High noise levels can severely tire a worker.

Physical Stress

To account for weight handling, the analyst must consider the amount of weight being handled, the manner in which it is handled, and the percentage of the work cycle that the worker handles the weight. Physical stress is considerably greater when a weight is lifted than if it is simply rolled or slid (1).

Physical stress is also largely affected by the working position. Little stress is felt by a worker who sits during much of the work cycle. A worker who must crawl into a tight spot and work in an unnatural position will experience great stress. Cost overruns can occur when the working position and other fatigue factors are not accurately identified. For example, welding a two-inch thick aluminum joint could cost 4.0 manhours per lineal foot under normal conditions. The same two-inch joint welded under close, cramped conditions could cost 4.0 manhours per lineal foot (4). If the proper PF&D was not applied to account for the difficult working position, this job would most likely be overexpended by 0.8 manhours per lineal foot or 20 percent over the cost bid to the customer. Since welding comprises a large portion of ship work. the cost overrun could be enormous.

Determining the fatigue allowance for mental and physical stress usually requires studying an operation throughout the work day. The actual effect on workers varies between individuals, based on their stature, diet, health, mental state (3), and other factors which the analyst can neither detect nor control.

To develop a reasonable fatigue allowance, the analyst must study the worker's performance over an entire shift. Normally, production increases during the early part of the shift, then falls off during the third hour. After the lunch break, production increases for a short period, then declines for the balance of the shift (3) - As with all studies, the more observations that can be made, the more accurate the study results. Any drop in productivity that cannot be attributed to other causes, such as personal time, poor worker health, or unavoidable delays, should be attributed to fatigue. The time to complete a single task (one work cycle) should be measured repeatedly throughout an entire shift. The difference between the time to produce one work cycle at the beginning of the shift and one work cycle at the end of the shift can be expressed as a

percentage. Any scheduled rest breaks should be subtracted from the total fatigue allowance.

Example:

A piece of equipment weighs 40 pounds and is lifted from the deck to the waist-high mounting location (3.45 percent weight allowance), working from a standing position (2 percent). This work requires the electrician's full attention (2 percent). The compartment temporary lighting intensity is less than 75 foot-candles (2 percent) and there is a constant, rather loud noise present (1 percent). The work will require more than 2.5 minutes to complete (0 percent). Adjacent operations require the electrician to wear a filter mask (5 percent).

The fatigue allowance is the sum of the item allowances, or 15.45 percent.

UNAVOIDABLE DELAY

Many things can occur during the work day to interrupt a worker's progress, many of them beyond the control of the worker. Machines require scheduled or unexpected maintenance, material supplies run out, power failures occur, a foreman must talk to the employee, or machines may require resetting. These types of delays must be considered when developing allowances for a time standard.

To determine the allowances required for unavoidable delays, the analyst should perform either a work-sampling (ratio-delay) study or a time study. A work sampling study, where instantaneous observations are made at randomly selected times, is the most efficient as it requires less of the analyst's time, interferes less with production, may be combined with other like studies, and is as accurate as a time study. Delays that should be included are those which are clearly beyond the control of the worker and that can reasonably be expected to occur during a given work day. Operator-caused (avoidable) delays should not be considered as allowances. Social calls, excessive gauging or counting of work pieces, starting late, quitting early, excessive personal time, or rework due to poor workmanship are not allowable parts of the work cycle. Delays that occur regularly or predictably, such as changing or sharpening tools after a fixed number of cuts or obtaining and disposing of a container of parts should be prorated

into the normal cycle time instead of the delay allowances (5).

Close trade coordination is required as an electrician holds an equipment template for a service welder (2 percent).

BALANCING (MACHINE) DELAY

Delays are common when a worker must move from one station to another to complete a work cycle. As the number of work stations increases, so do the delays encountered. The amount of delay depends on the number of facilities assigned, the randomness of the moves, the ratio of servicing time to running time, the length of running time, and the average length of servicing time (3). Delays are encountered when the worker must wait for another worker to complete an assignment on the same machine, for repairs to be performed on a machine, for cleaning and oiling a machine, or to gather and return tools.

To develop the allowance for balancing (machine) delay, the work can be observed through a time study or a work-sampling (ratio-delay) study. The analyst must determine which of these techniques is the most practical for the application. These delays should be prorated into the normal cycle time, rather than into the allowances, if they occur consistently.

COMPLEXITY OF WORK

There is no precise way to measure the magnitude of work complexity. In operations where there is a large amount of repetition over a short cycle, there is rarely a need to compensate for complexity. Workers tend to become automated in their tasks and the learning time is so short that it may be negligible. Where an operation with a long cycle time requires the assembly of many parts of different sizes and shapes, as in ship work, the learning time may be long. Performing these kinds of tasks never becomes fully automatic and the assignment may be completed before full productivity is attained. Repetition on these jobs is low and the memory requirement is high. This allowance should not be confused with mental fatigue, which is the slowing of production due to stress. Complexity allowances are made to compensate for the time required to perform the mental 'processes.

To properly allow for complexity of work, the analyst must consider the

required degree of mental activity and the duration of the work cycle. Thinking and deciding, reading instructions, and referring to a model all require thought on the part of the operator. The number of repetitions of the work cycle, the duration of the job, and the employee turnover rate determine the learning exposure the employee has.

In activities such as ship repair, a good approach is to generally study all plant operations and develop a normalizing factor, which is a weighted average considering the pace of personnel and the performance of equipment. This normalizing factor is then applied to the normal time before the PF&D allowance. This normalizing factor is developed only once for the entire plant and is applied universally to all operations. This approach is especially useful when motion-time analysis or standard data is used to develop the normal time for low-repetition operations, such as those dealing with repair work.

SPECIAL ALLOWANCES

Special allowances are those that fit into no specific category but must be applied to arrive at a fair standard. Typical examples of these allowances are mustering of personnel at shift changes, clean-up of the work site, and other odd items that cannot be defined as personal, fatigue, and delay or be prorated into the normal time. The analyst can time study each special allowance item or observe them by work sampling. Some organizations have time set aside for these operations, either formally or informally. The analyst should check policies regarding special allowances before applying them.

Example:

An electrician is required to report to a five-minute muster four times a day for a total of 20 minutes (4 percent). Work site cleanup requires 10 minutes per day (2 percent). The total of special allowances is 6 percent.

APPLYING ALLOWANCES

After the analyst has determined all of the personal, fatigue, and delay elements, he must apply them to the normal time. This is done by developing a multiplier for an eight-hour day.

The example allowances are expressed as percentages of the shift. They must be summed (37.45 percent) and applied to the formula:

$$AF = \frac{100}{(100 - p)} \quad (1)$$

where:

AF = allowance factor, and

p = total of element percentages

Example :

$$AF = \frac{100}{(100 - 37.45)} \quad (2)$$

$$AF = 1.60$$

If the allowances are expressed in minutes (179.76), the formula is:

$$AF = \frac{480}{(480 - m)} \quad (3)$$

where:

AF = allowance factor, and

m = total of element times in minutes

Example:

$$AF = \frac{480}{(480 - 179.76)} \quad (4)$$

$$AF = 1.60$$

The normal time is then multiplied by the allowance factor to yield the true standard time.

Example: The analyst has determined that the normal operation time is 0.75 manhours. The actual standard manhour allowance is calculated as follows:

$$0.75 \text{ M/H} \times 1.60 \text{ (AF)} = 1.2 \text{ M/H} \quad (5)$$

SUMMARY

Allowances for the non-work elements in a work cycle are an important part of a time standard. These allowances should not be used as a 'dumping ground' for missed elements, but as a fair accounting of the non-productive elements which are part of a typical work day. Job conditions must be observed and analyzed to determine the true conditions and which allowances apply to the work cycle. The analyst should use the study as an opportunity to seek method improvements which will eliminate work delays and fatigue factors. The methods used must be consistent and objective. Work measurement techniques such as time

study or work-sampling should be used to determine the actual duration of the PF&D elements. Due to varied interpretations by work analysts (1), organizations should establish policies and standardized allowances. They may be itemized or simply blanket allowances, but all conditions must be considered. The penalty for ignoring PF&D is always a higher-than-predicted product cost which can quickly become lost business.

REFERENCES

1. Standardization of Work
Measurement
DoD 5010.15.1-M. Volume 1, August 1977
2. Engineered Work Measurement
Delmar W. Karger & Franklin H. Bayha
c 1957 The Industrial Press
3. Motion and Time Study
Benjamin W. Niebel
c 1955 Richard D. Irwin. Inc.
4. Standard Data Tables for
Structural Production Welding,
Philadelphia Naval Shipyard
5. Industrial Engineering
Handbook
H.B. Maynard, Editor-in-Chief
c 1956 McGraw-Hill Book Co., Inc.

Additional copies of this report can be obtained from the
National Shipbuilding Research and Documentation Center:

<http://www.nsnet.com/docctr/>

Documentation Center
The University of Michigan
Transportation Research Institute
Marine Systems Division
2901 Baxter Road
Ann Arbor, MI 48109-2150

Phone: 734-763-2465
Fax: 734-936-1081
E-mail: Doc.Center@umich.edu